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AUTHOR Tennyson, Robert D.; Rasch, Mariana
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ABSTRACT

This paper proposes a basic instructional design model that focuses on the planning of a learning environment so that students not only acquire factual knowledge, but also improve their cognitive abilities to use and extend their knowledge. The model describes the direct relationships between learning time, cognitive objectives, memory system components, and instructional strategies; thus, learning times are directly allocated to specific cognitive learning objectives and instructional methods. It is suggested that the acquisition of conceptual knowledge and development and improvement of thinking strategies and creativity should account for about 70% of the learner's formal learning time, and that the remaining time should be allocated to the acquisition of information. Five instructional methods that have direct relationships to specific cognitive-based objectives are also discussed, i.e., drill and practice, tutorials, task-oriented simulations, problem-oriented simulations, and self-directed experiences. A diagram of the model is provided. (33 references) (EW)

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Instructional Design for the Improvement of Learning and Cognition

Robert D. Tennyson

and

Mariana Rasch

University of Minnesota

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Robert D. Tennyson, Department of Educational Psychology, University of Minnesota, 178 Pillsbury Dr. S.E., Minneapolis, MN 55455

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Instructional Design for the Improvement of Learning and Cognition

The purpose of this paper is to present a cognitive-science based instructional planning and design model that deals directly with the educational goals of both knowledge acquisition (i.e., learning) and employment (i.e., cognition). The model describes the direct relationship between specific cognitive-based objectives and instructional methods. Within this context, we follow Gagne's (1985) premise that unique instructional methods directly improve specific learning and thinking processes. Thus, we propose an instructional planning and design model by which to link cognitive processes and objectives to specific instructional methods. An additional feature of our planning and design model is the direct reference to instructional time allocations for each cognitive-based objective (see Figure 1).

Instructional Planning and Design Model

In this paper we present a basic model for planning the learning environment that proposes application of cognitive learning theory with specific instructional methods (Figure 1). In other sources are presented the empirical findings that support the instructional methods in terms of their affect in improving learning and cognition (for a review of the empirical findings see Tennyson & Breuer, 1984; Tennyson & Cocchirella, 1986; Tennyson, Thurlow, & Breuer, 1988). Our purpose in this paper is to propose an instructional design model that focuses on the planning of a learning environment so that students not only acquire knowledge but also improve their cognitive abilities to employ and extend their knowledge.

Insert Figure 1 about here

Educational leaders have recently renewed their call for planning of learning environments that exhibit, in addition to acquisition of information (or content), the learning of higher-order thinking strategies (e.g., Savell, Twohig, & Rachford, 1986) and the development cognitive abilities. However, two major problems persist in the implementing of such goals. The first is the continuing assumption that appropriate instructional methods are not available. And, second, that improvement in cognition occurs through some independent system external to the mainstream curricular programs. For example, that thinking skills can be acquired through the practice of generic strategies and then latter transferred across any domain of information (i.e., Feuerstein, Rand, Hoffman, & Miller, 1980). However, our thesis here is that both problems can be solved.

First, educational research in the past two decades has investigated instructional variables and conditions that show dramatic improvements in both knowledge acquisition and employment (Reiser, 1987). Thus, it is possible to define in concrete terms instructional methods that can improve both cognitive goals.

LEARNING ENVIRONMENT

	ACQUISITION OF KNOWLEDGE BASE (Storage)			Employment & Improvement of Knowledge Base (Retrieval)	
LEARNING TIMES	10%	20%	25%	30%	15%
COGNITIVE-BASED OBJECTIVES	VERBAL INFORMATION	INTELLECTUAL SKILLS	CONDITIONAL INFORMATION	THINKING STRATEGIES	CREATIVITY
MEMORY SYSTEMS	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	CONCEPTUAL KNOWLEDGE	COGNITIVE COMPLEXITY	TOTAL COGNITIVE SYSTEM
INSTRUCTIONAL STRATEGIES	DRILL & PRACTICE METHODS	TUTORIAL METHODS	TASK-ORIENTED SIMULATIONS	PROBLEM-ORIENTED SIMULATIONS	SELF DIRECTED EXPERIENCE

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Second, research findings strongly indicate that higher-order thinking strategies are best learned within the context of conventional subject matters (Resnick, 1981). That is, panaceas with quick-study, domain-independent methods do not provide the conceptual knowledge necessary to improve accessibility of information in the knowledge base. Although research continues on instructional variables and strategies, there are currently available instructional methods that can immediately meet the educational goals of improving both knowledge acquisition and employment (Gagne, 1987).

A key factor in implementing the cognitive goals of knowledge acquisition and employment is the allocation of learning time with instructional methods within a curricular context (See Kulik & Kulik, 1984, for a review on performance and instructional time). For example, Goodlad (1984) suggested, from his research findings on classroom time and instructional activities, that a significant change in instructional time allocated to various learning activities must be done if improvements in problem solving and creativity were to occur. He recommended that the conventional instructional time allocation for learning be altered so that, instead of 70% of instruction be aimed at the declarative and procedural knowledge levels of learning, 70% be devoted to learning and thinking situations that involve acquisition of conceptual knowledge and development of cognitive abilities. And, that these instructional situations be done within the subject matter areas, not external to them.

Using Goodlad's recommended figures on instructional time allocation, we propose that 70% of formal, classroom learning time use instructional methods that focus on higher-order learning and cognition. In Figure 1, we present an instructional planning model of the learning environment that shows the direct relationships between learning time, cognitive objectives, memory systems components, and instructional strategies. Figure 1 shows a time allocation guideline for curriculum planning such that the goals of knowledge acquisition and employment can be traced between cognitive objectives and specify instructional methods.

Memory Systems

The acquisition of information and the means to employ information occurs within the storage and retrieval subsystems of the long-term memory component (Tennyson & Breuer, 1984). The storage system is where coded information is assimilated into the existing knowledge base. A knowledge base can be described as an associative network of concepts (or schemas) varying per individual according to amount, organization, and accessibility of its information (Rabinowitz & Glaser, 1985): amount refers to the actual volume of information coded in memory, while organization implies the structural connections of that information, with accessibility referring to the executive control strategies used in the service of thinking (i.e., recall, problem solving, and creativity). The latter two forms of knowledge are those that separate an expert from the novice. That is, a large amount of information is not the key to expert thinking, but rather the ability to both find and employ information appropriately.

Within storage there are various forms of knowledge: declarative, procedural, and conceptual (Shiffrin & Dumais, 1981). Each form represents a

different memory system or function. Declarative knowledge implies an awareness of information and refers to the "knowing that," for example, that underlining keywords in a text will help recall. Procedural knowledge implies a "knowing how" to use given concepts, rules, and principles. Conceptual knowledge implies an understanding of "knowing when and why" to select specific concepts, rules, and principles. This executive control process of knowing when and why, is governed by selection criteria embedded within the organization of the knowledge base. Criteria are the values and situational appropriateness by which connections within the schematic structure of a knowledge base are made. Whereas both declarative and procedural knowledge form the amount of information in a knowledge base, conceptual knowledge forms its organization and accessibility.

The retrieval system employs the cognitive abilities of differentiation (i.e., selection) and integration (i.e., restructuring) in the service of thinking strategies associated with recall, problem solving, and creativity. Recall strategies employ only the automatic selection (i.e., differentiation) of knowledge directly as stored in memory. Problem solving strategies, on the other hand, require both cognitive abilities of differentiation and integration and are formed at the time of solution and stored as conceptual knowledge. That is, problem solving strategies are domain specific and cannot be considered as generic "skills" that can be transferred between domains. Therefore, the accumulation of problem solving strategies in the knowledge base occurs in direct reference to number of problems solved within given domains. Creativity strategies, in addition to employing differentiation and integration, make use of the cognitive ability to create knowledge not already coded in memory (Dehen & Schank, 1982).

In summary, all three kinds of thinking strategies are acquired while using the cognitive abilities of differentiation, integration, and creation. Each strategy form is embedded by domain within the conceptual knowledge structure of the knowledge base. Therefore, as the learner engages in more thinking situations, the individual strategies become increasingly more abstract and generalizable within the domain (Sternberg, 1985).

Cognitive Complexity.

As stated above, thinking strategies employ the three cognitive abilities of differentiation, integration, and creation of knowledge. The first two abilities occur primarily in the retrieval system of memory while the third further involves the other components of the entire cognitive system (see Figure 1).

The operational term for the retrieval system functions of differentiation and integration is cognitive complexity (Schroder, 1971). Cognitive complexity, as contrasted to intelligence, is an ability that can be developed and improved (Streufert & Swezey, 1986). Differentiation is defined as follows: (a) the ability to understand a given situation; and (b) the ability to apply appropriate conceptual criteria (i.e., the standards, situational appropriateness, and/or values) by which to select necessary knowledge from storage. Integration is the ability to elaborate or restructure existing knowledge in the service of the given problem situation. Creativity is the

ability to form new declarative and procedural knowledge as well as conceptual knowledge by using the total cognitive system.

Learning Time

The allocation of learning time is divided between the two main subsystems of long-time memory--storage and retrieval. Within the guidelines illustrated in Figure 1, time is assigned according to the memory systems defined in the previous section. In the storage system, learning time is allocated among the three memory systems making up a knowledge base as follows: declarative knowledge 10%; procedure knowledge 20%; and conceptual knowledge 25%. We are recommending that conceptual knowledge learning time be about equal to the other two knowledge forms because of the necessity in acquiring information to both organize a knowledge base and develop accessibility. The value of a knowledge base is primarily in the functionality of its organization and accessibility. Without a sufficient base of conceptual knowledge, the opportunity for employment, future elaboration, and extension of the knowledge base is severely limited (for example, see Bransford & Johnson, 1972; Brown, 1978; Rohwer, 1975).

For the knowledge acquisition goal, the focus of our learning time allocation is on conceptual knowledge, and away from the usual practice of heavy emphasis on amount of information. We are assuming that content knowledge acquisition is an interactive process that is improved when employing the knowledge base in the service of higher-order thinking situations (i.e., problem solving and creativity). Time allocated for declarative and procedural knowledge focuses on establishing an initial base of necessary content knowledge that can be used within a context of a problem situation. That is, learning time should include the opportunity for the learner to gain experience in employing the knowledge.

The learning times presented in Figure 1 do not imply a linear sequence of knowledge acquisition going from declarative to conceptual. Rather, they represent total amounts in an iterative learning environment where learners are continuously acquiring each form of knowledge. For example, students may engage in conceptual knowledge acquisition prior to declarative knowledge acquisition if they currently have sufficient background knowledge (i.e., a discovery method of instruction as contrasted to a structured method).

Cognitive-based Objectives

The purpose of cognitive-based objectives is to further elaborate the curricular goals of knowledge acquisition and employment. Objectives are important in the planning of learning environments because they provide the means of both allocating learning time and identifying specific instructional methods. Also, unlike behavioral objectives which only state measurable desired end of instruction outcomes, cognitive-based objectives imply a given cognitive process of learning or thinking.

In terms of learner assessment, the cognitive-based objectives that deal directly with the acquisition of declarative and procedural knowledge (see Figure 1) provide for quantitative measures of specific domain information. However, the cognitive-based objectives for conceptual knowledge acquisition

and improvements in thinking are more subject to reflective evaluations rather than the usual correct or incorrect assessments associated with the learning of content information. That is, it is far easier to test a knowledge base for amount of information than it is to measure the organization and accessibility.

The cognitive-based objectives presented here are for the most part taken from Gagne's (1985) classification of learning outcomes. Whereas Gagne prefers to lump all thinking processes into one category of human capability (i.e., cognitive strategies), we prefer a system of objectives that provides for more basic distinctions between the various forms of thinking. This allows for improved clarification of both instructional outcomes and methods. Thus, there is a direct trace between memory system components and objectives and learning time. We define cognitive-based objectives as follows:

-Verbal information. This objective deals with the learner acquiring an awareness and understanding of the concepts, rules, and principles within a specified domain of information (i.e., declarative knowledge). The specific concepts to be learned is identified by an information analysis procedure that shows the schematic organization of the domain as well as the individual concepts. An analysis of the information to be learned is a highly important procedure in instructional design because it provides the instructional sequence by which information can be presented. That is, a structured sequence enhances the learner's initial organization of a knowledge base see Tennyson, 1981, for a complete review of an information analysis).

-Intellectual skills. This objective involves the learner acquiring the skill to correctly use the concepts, rules, and principles of a specified domain of information (i.e., procedural knowledge). For example, the classification of unencountered examples of a given concept. Classification is the intellectual skill by which learners to both discriminate and generalize unencountered examples. The intellectual skill for a rule, is the ability to use the rule correctly in the solving of an unencountered problem.

-Conditional information. This objective focuses on the learner's acquisition of a knowledge base's organization and accessibility (i.e., conceptual knowledge). The organization of a knowledge base refers to the schematic structure of the information whereas the accessibility refers to the executive control strategies that provide the means necessary to employ the knowledge base in the service of recall, problem solving, and creativity. Conceptual knowledge includes the criteria, values, and appropriateness of a given domains schematic structure. For example, simply knowing how to classify examples or knowing how to use a rule (or principle) does not imply that the learner knows when and why to employ specific concepts or rules. Therefore, this objective defines a learning environment where the learner can develop both the associative network of the knowledge base (i.e. organization) and the control strategies to effectively employ the knowledge (i.e., accessibility).

-Thinking strategies. This objective deals with both the development of cognitive complexity abilities and the improvement of domain specific strategies of thinking. Thus, this category of cognitive-based objectives deals with two important issues in education. First, the

elaboration of thinking strategies that will arm the students with increased domain specific conceptual knowledge. As stated earlier, thinking strategies are domain-dependent and are only transferable between domains at the most abstract levels of possible employment. For example, knowing the scientific method of inquiry does not in and of itself provide sufficient information to transfer across disciplines without the further acquisition of more concrete domain-dependent application concepts. Second, the development of the cognitive abilities of differentiation and integration. These abilities provide the cognitive tools to effectively employ and improve the knowledge base; therefore, they are integral to any educational goal seeking to improve thinking strategies.

-Creativity. This objective deals directly with the most elusive goal of education, and that is, the development and improvement of creativity. We defined creativity as a two fold ability: First, creating knowledge to solve a problem from the external environment; and, second, creating the problem as well as the knowledge. Integral to the creating of both the problem and knowledge is the criteria by which consistent judgement can be made. Again, we define two forms of criteria. The first is criteria that are known and which can be applied with a high level of consistency. In contrast are criteria that are developed concurrently with the problem and/or knowledge, and is consistently applied across a high level of productivity. Creativity objectives need to specify not only the ability to develope and improve, but also the form of criteria. That is, students should be informed of the criteria in the former and, in the latter, the necessity to develop criteria.

Instructional Methods

In this section, we identify instructional methods that have direct relationships to specific cognitive-based objectives. Also, these methods (or strategies) are composed of instructional variables that have rich empirical-bases of support. That is, instead of prescribing a given strategy of instruction for all forms of learning, we have identified general categories of strategies, each composed of variables that can be manipulated according to given instructional situations.

The five instructional categories are as follows:

Drill and practice. This category represents those instructional strategies designed to provide a practice environment for learning declarative knowledge. The two basic instructional forms of practice within this category are worked examples and question/problem repetition. These in turn can be further elaborated by various forms of branching and ratio repetition between correct and incorrect patterns of response (see Salisbury, 1988, for a complete review of drill and practice strategies).

Worked examples is a practice environment in which the information is presented to the student in an expository form. The purpose is to help the student in understanding both the context of the information and the structure of information (i.e., organization). For example, to learn a mathematical operation, the student is presented the steps of the process in an expository problem concurrently, presenting explanations for each step. In this way, the

student can clearly understand the procedures of the mathematical operation without developing possible misconceptions often occurring with discovery methods of teaching (Petkovich & Tennyson, in press).

The question/problem strategy presents selected information repeatedly until the student answers or solves all items at some predetermined level of proficiency. The purpose here is to efficiently acquire the amount of information in a knowledge base. Differences in question/problem strategies come from the manipulation of the ratio between correct and incorrect responses. Context is important here because of the students background knowledge can determine whether massed practice is better than variable. If a student, for example, has good background knowledge, massed practice may be more efficient because of an existing organized knowledge base. On the other hand, if the student does not have background knowledge in which to elaborate, variable practice may be better because the student needs to develop some organizational context for the information in addition to just the amount of information.

Tutorials. This category of instructional strategies contains a rich variety of variables and conditions to manipulate to improve learning. This category is labelled tutorial because the objective is to learn how to use knowledge correctly, therefore, it requires constant intervention between student application (e.g., problem solving) and instructional system monitoring. Tutorial strategies attempt to create an environment where the student learns to apply knowledge to unencountered situations while being carefully monitored so as to both prevent and correct possible misconceptions of procedural knowledge.

The basic instructional variable in this strategy is the presentation of interrogatory (question) problems that have not been previously encountered (see Tennyson & Cocchiarella, 1986, for a complete review of variables in this category). Other variables include means for evaluation of learner responses (e.g., pattern recognition), advisement (or coaching), elaboration of basic information, organization of information, number of problems, use of expository information, error analysis, and lastly, refreshment and remediation of prerequisite information (Tennyson & Christensen, 1988). In schooling environments, peer tutoring has been shown to improve learning when tutors are trained with the above variables and are matched intellectually with the tutee. More recently, computer-based tutorial systems have employed advanced rule-based methods of programming to develop machine-intelligent applications of the above variables. Only the MAIS system has successfully employed more than one of the above variables in an intelligent computer-assisted instructional program (Tennyson & Park, 1987).

Task-oriented simulations. In the instructional planning model (see Figure 1), we propose that 25% of the instructional time be devoted to the acquisition of conceptual knowledge. The proposed instructional strategy for this category uses a simulation technique. The purpose of simulations is to improve the organization and accessibility of information within a knowledge base by presenting problems that require the student to search through their memory to locate and retrieve the appropriate knowledge to propose a solution. Within this context, the simulation is a problem rather than an expository demonstration of some situation or phenomenon.

In most discussions of knowledge base organizations, the specification of this accessibility process is elusive. However, in the field of artificial intelligence, the accessibility process is the most important function of an intelligent system. Within expert systems, conceptual knowledge is represented in the form of the search rules. These rules are often in the form of production rules (e.g., IF THEN statements) or higher-order, meta rules. More advanced AI systems use fuzzy logic rules or conditional probability hueristics to account for situations that require inferences that do not result in only dichotomous outcomes.

Human memory systems, however, unlike computer-based AI systems, can self-generate the conceptual knowledge of the knowledge base. The instructional key to improving this human cognitive process, is the opportunity for the learner to participate in solving domain-specific problems that have a meaningful context. Unlike problems in the tutorial strategies that focus on acquiring procedural knowledge, simulations in this category exhibit tasks that require employment of the domain's procedural knowledge. Thus, the student is in a problem solving situation that requires establishing connections and associations between the facts, concepts, rules, and principles of specific domains of information.

Task-oriented simulations present domain specific problem situations to improve the organization and accessibility of information within the knowledge base. Basically, the strategy focuses on the student trying to use their declarative and procedural knowledge in solving domain-specific problems. Task-oriented simulations present task situations that require the student to (a) analyze the problem, (b) work out a conceptualization of the problem, (c) define specific goals for coping with the problem, and (d) propose a solution or decision.

To help students acquire a richer schematic network for their knowledge base, cooperative learning group techniques become an integral component of the task-oriented simulation strategy. Within heterogeneous groups, students present and advocate their respective solutions to problems posed by the simulation. Research findings indicate that socialization is an important condition in the improvement of conceptual knowledge acquisition (e.g., Wagner & Sternberg, 1984). That is, the process of advocacy and controversy within the group provides an environment for students to both elaborate and extend their conceptual knowledge. In other words, task-oriented simulations add practical experience to the knowledge base not usually acquired until placed in a "real world" environment.

Problem-oriented simulations. Instructional methods for developing thinking strategies are often employed independent of the learners knowledge base. For example, Feuerstein, Rand, Hoffman, and Miller (1980) present an elaborate training program to teach thinking skills by having students practice problem solving methods with nonsense tasks. The assumption is, that after learning a set of generic, domain-independent problem solving skills, these skills can be transferred to domain specific situations. However, independently derived empirical findings of such training programs show little, if any transfer (Frederiksen, 1984). Part of the explanation for the failure of such transfer, is that when domain-specific instruction is given, the focus is on acquisition of declarative and procedural knowledge rather than either acquisition of conceptual knowledge or thinking strategy

development. Also, given the complexity within the organization of a knowledge base, thinking skills do not provide sufficient means to cope with any but the most simplest of problems (Gagne & Glaser, 1987).

In contrast to the many training systems for domain-independent thinking skills development, simulations that present domain-specific problem situations, allow learners to develop their thinking strategies while employing the domain knowledge stored in their memory system. Problem-oriented simulations extend the format of the task-oriented simulations by use of an iterative problem format that not only shows the consequences of decisions but also updates the situational conditions and proceeds to make the next iteration more complex. That is, the simulation should be longitudinal, allowing for increasing difficulty of the situation as well as providing the adding and dropping of variables and conditions. In more sophisticated simulations these alterations and changes should be done according to individual differences. Instructional variables and conditions of a problem-oriented simulation are as following:

-Situations that have a meaningful context (i.e., not a game) that require the learners to use their own knowledge base;
-Complex situations to challenge the learners differentiation process;
-Situations that exposes learners to alternative solutions to improve their integration process;
-Situations in which learners see challenging alternatives within each learner's own level of cognitive complexity;
-Situations that learners view as environmentally meaningful to develop conceptual criteria;
-Situations that use reflective evaluation rather than right or wrong answers to develop learners higher-order conceptual criteria;
-Situations that allow for continuous development of higher-order thinking strategies;
-Situations that allow learners to see consequences of their solutions and decisions; and
-Situations that allow for predicting value of future states of the situation.

The main features of problem-oriented simulations are: (a) to present the initial variables and conditions of the situation; (b) to assess the learner's proposed solution; and (c) to establish the next iteration of the variables and conditions based on the cumulative efforts of the learner.

To further enhance the development and improvement of higher-order thinking strategies, we propose the employment of cooperative learning methods. Research findings (e.g., Breuer, 1985, 1987) indicate that intra-group interactions in problem-solving situations contribute to cognitive complexity development because the learners are confronted with the different interpretations of the given simulation conditions by the other group members. In this way, new integrations between existing concepts within and between schemata can be established, alternative integrations to a given situation can be detected, and criteria for judging their validity can be developed.

An important issue in cooperative learning is the procedure used to group students. Most often, when cooperative learning groups are used for knowledge acquisition, the students are organized according to heterogeneous variables, such as gender, socio-economic, intelligence and achievement. However, our

research shows that for development of thinking strategies, group members should have similar abilities in cognitive complexity. That is, within groups, students should be confronted with solution proposals that are neither too much above or below their own levels of complexity.

For example, students with low cognitive complexity become frustrated and confused with highly sophisticated solutions, while students with high cognitive complexity are not only not challenged but become quickly bored with less sophisticated solutions.

The format of the group activity should employ a controversy method where a consensus is reached following a discussion of proposals independently developed and advocated by each member. This format is in contrast to the compliance method where a consensus is reached by members working together from the start.

The controversy method can be explained in the following example which uses a computer-management system:

1. The problem situation is presented to the students. The computer-based simulation prints out the initial conditions of the situation.
2. The students on an individual basis study the situation and prepare an independent proposal.
3. The students reassemble as a group to present their proposals. In the initial presentation, the students are to advocate their position.
4. Following the initial presentations, the students are to continue advocacy of their proposals in a debate fashion. The concept of the controversy method is used to help the students further elaborate their positions as well as seeing possible extensions and alternatives
5. The final goal of the group session is to prepare a cooperative proposal to input into the simulation. This consensus is reached only after a complete debate and should represent the group's "best" solution.
6. The computer program will then update the situation according to the variables and conditions of the simulation. The steps are then repeated until the completion of the simulation.

In summary, problem-oriented simulations are designed to provide a learning environment in which learners develop and improve higher-order thinking strategies by engaging in situations that require the employment of their knowledge base in the service of problem solving.

Self-directed experiences. Creativity seems to be a cognitive ability that can be improved by learners engaging in activities that require novel and valuable outcomes. As Gagne (1985) has often written, creativity can be improved by instructional methods that allow students the opportunity to create knowledge within the context of a given domain. Instructional programs that provide an environment for easy manipulation of new information increase the learning time available for such activities. An example of such an environment is LOGO (Papert, 1980), a computer-based software program within the domain of mathematics. LOGO is especially helpful for those students who currently have a good declarative and procedural knowledge base of mathematics and need to elaborate their organization and accessibility of that knowledge.

Other computer-based software programs provide environments for self-directed learning experiences that may improve creativity within given domains. For example, word processing programs have been shown to improve writing skills because of the ease in correcting and adjusting text structure (Lawler, 1985). Computer-based simulations have also shown that creativity can be improved when students can both continually see the outcomes of their decisions while understanding the predictability of their decisions.

Creativity seems to be a cognitive ability that can be improved with use within a domain, and that computer-based software programs seem to provide the type of environment which can enhance instructional methods for such improvements (Collins & Stevens, 1983). Because of the time necessary for participating in creative activities, educators should provide sufficient learning time for such development (Tennyson et. al., 1988). Computer software programs that are domain specific enhance the cost-effectiveness of instructional strategies aimed at the improvement of creativity.

The key instructional attribute for this category is an environment that allows students to experience creativity in at the moment "real" time. Computer software programs that are domain specific and allow for self-directed learning seem to offer the best instructional method for meeting goals of a curriculum that emphasizes higher-level thinking strategies.

Conclusion

The purpose of this paper was to present a model of the learning environment that directly allocates learning times with specific cognitive learning objectives and instructional methods. We proposed that learning time be allocated according to acquisition and employment of a learner's knowledge base. The emphasis of the model is that acquisition of conceptual knowledge and development and improvement of thinking strategies and creativity account for 70% of a learners formal learning time, and that the remaining time be allocated to acquisition of information. Because of the focus on conceptual knowledge and thinking strategies and creativity in relationship to domains of information, as contrast to learning information and thinking strategies as independent instructional methods, declarative and procedural knowledge would be further acquired by the process of elaboration and iteration provided in the instructional methods of simulations and self-directed experiences.

In conclusion, the learning environment model stresses that currently there exist sufficient instructional strategies to improve student learning in each of the areas of the learning/thinking processes. That is, although there needs to be continued research in variables and conditions of instruction, there are predictable instructional prescriptions available to now improve both learning and thinking. Also, we recognize that there are other goals of any educational curriculum not discussed in this model and that they need to be considered when designing a comprehensive curriculum. Our concern was to focus only on the variables and conditions of instruction for the improvement of knowledge acquisition and employment. The meta-learning model provided us with the opportunity to look at the whole range of learning objectives without the constraints of meeting the conditions of a given learning or instructional theory. It was within that context that we were able to define meta-instructional methods with prescribed learning times.

Our hope is that this instructional planning model will offer a baseline for further discussion on the important issue of instructional time and the improvement of learning.

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